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(54) COMPOSITION OF MATTER FOR LIMITING DEHYDRATION AND FATIGUE DURING PERIODS OF PHYSICAL EXERTION

(71) We, STOKELY-VAN CAMP, INC., a corporation organised under the laws of the State of Indiana, United States of America, of 941 N. Meridian Street, Indianapolis, Indiana, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to a novel compositions of matter for replacing body fluids, salts and minerals lost by an individual during vigorous physical activity and more particularly relates to a method of limiting dehydration of such individuals during the periods of vigorous activity particularly in areas of heat and excessive temperatures.

This invention also contemplates compositions of matter which maintain proper balance and ratios of certain concentration of ions and salts present in body fluids.

It is well known that there are a great many heat related diseases reported yearly. Individuals suffering from heat related diseases many times have engaged in vigorous physical activity in a relatively hot climate. The problem of heat related diseases is particularly acute among athletes and more particularly among those athletes wearing protective clothing which, for the most part, prevents heat dissipation.

More than ninety percent of the heat dissipated by the body is lost through conduction, convection, radiation and vaporization of water. Heat lost through these routes varies greatly with the environmental temperature, the amount and nature of clothing worn and the amount of heat produced by the body. When environmental temperature is below 28 to 30°C., vaporization of water from the skin is of minor importance as a mechanism for dissipation of heat. However, as the environmental temperature rises, vaporization becomes increasingly more important until about 35°C. when it is virtually the sole means of heat loss.

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Effective vaporization of water depends on the ability of the surrounding air to absorb additional moisture and is thus affected by the humidity as well as the type and amount of clothing worn. It is not surprising, then, that football players, encased in " suits of armor ", have great difficulty dissipating heat produced during vigorous exercise. The efficiency of radiation, conduction and convection as mechanisms for heat loss is almost completely vitiated by the protective clothing worn. Vaporization of water, also made less efficient, then becomes the principal route of heat loss.

Deaths from heat related diseases among athletes have been reported yearly. These occur most frequently during the first few weeks of football practice in the late summer. Since ingestion of water during vigorous physical activity tends to produce cramps, it has been common practice among coaches and trainers to provide athletes with liberal amounts of salt to replace the lost salt, but to restrict water ingestion during practice sessions and games to prevent the nausea, vomiting and abdominal cramps.

While both a rapid profound loss of salt and water occurs in the individual working vigorously in a hot climate, the loss of water far exceeds the loss of salt. Therefore, the sodium chloride in the body becomes concentrated and administration of salt, without water during exercise, aggravates the physiologic disturbance and increases the likelihood of serious heat illness.

Therefore, there is a need to provide a method to supply an adequate source of volume replacement to individuals undergoing vigorous exercise which will improve performance, prolong tolerance to heat without concomitant side effects, abate fatigue and limit the dangers associated with heat exhaustion. There have been no satisfactory answers to the problem of replacing fluid volume during vigorous physical exercise in a hot climate. Therefore, it is a primary object of the present invention to provide a method for satis-

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factorily preventing dehydration with the resulting fatigue, loss of tolerance to heat and dangers associated with heat exhaustion.

Embodiments of this invention will now be described by way of example with reference to the accompanying drawings, of which:

Figure 1 is a graphic representation of weight, extracellular volume and plasma volume before and after exercise.

Figure 2 is a graphic representation of in plasma osmotic pressure before and after exercise.

Figure 3 is a graphic representation of changes in plasma sodium and potassium and in plasma osmotic presure before and after exercise.

Figure 4 is a graphic representation of changes in plasma phosphate and protein before and after exercise.

Figure 5 shows the concentration of sodium and potassium of perspiration, the estimated water loss and the total sodium and potassium loss.

Figure 6 is a graphic representation of blood glucose before, during and after exercise.

Figure 7 is a graphic representation of serum lipid before, during and after exercise.

An individual, such as an athlete, exercising vigorously, will lose large amounts of water and body salts. These salts are generally the salts of sodium and potassium such as their chlorides. In order to determine the precise changes which occur during exercising, ten subjects were studied each day for five days during a period of athletic activity. All observations were made with the subjects at rest before a regular practice session and again immediately after two hours of vigorous exercise during which nothing was ingested. The most striking changes were the loss of water which averaged 2.4 liters. As extracellular volume decreased by 2.1 liters, almost the entire loss of fluid was from the extracellular space while intracellular water was well maintained. Both extracellular volume and plasma volume decreased proportionately, the average decrease in extracellular volume being 12% and in plasma volume 11%.

Since sweat is a hypotonic solution, even when sweating occurs at a rapid rate, the loss of water significantly exceeds the loss of sodium. In spite of massive sodium losses, this results in a rise in plasma sodium concentration and a proportionate rise in osmotic pressure.

Although potassium loss averaged 103 meq. during the two hours of exercise, no consistent change in plasma potassium concentration occurred. The decreased volume in which potassium is distributed after exercise may in part explain the failure of plasma potassium to reflect the measured potassium losses. The remarkably stable serum potassium was probably due to mobilization of stores from the intracellular spaces.

No phosphate was found in the sweat. The fall in plasma phosphate concentration was most likely due to utilization of phosphate in the metabolism of glucose. That glucose is utilized at a rapid rate during exercise has been well established. Although blood glucose concentration fell in the subjects studied, the relative stability after 20 and 30 minutes of exercise indicates significant gluconeagenesis occurred.

The increased plasma protein concentration following exercise is undoubtedly a result of water loss and shrinking of the plasma volume; an increase in serum lipid concentration during exercise and the very rapid fall in the post exercise period apparently is the result of rapid mobilization of fat stores.

The above observations can more fully be noted in the Figures. In Figure 1 is plotted the weight, extracellular volume (ECF) and plasma volume before and after exercise. It is apparent that weight dropped sharply in all subjects, a range between 1.3 and 3.7 Kg gave a mean weight loss of 2.6 Kg or 2.9% of the body weight. Extracellular volume also fell sharply an average of 2.0 liters or 12% of the ECF extracellular volume. Plasma volume fell an average of 500 ml or 11% of the control volume. Almost the entire fluid loss was from the extracellular space with both interstitial and plasma compartments shrinking in proportion while the intracellular space was well maintained.

In Figure 2 the weight loss is plotted against water loss as determined by dilution of tritiated water. Three subjects were examined and each lost weight slightly in excess of his water loss; the ratio of water loss to weight loss averaged 0.93.

In Figure 3 changes in plasma sodium and potassium and in plasma osmotic pressure are shown. In nine out of 10 subjects, plasma sodium increased from 1.0 to 7.0 meq/liter. The mean rise for the entire group was 2.6 meq/liter. Plasma potassium increased slightly in four and fell slightly in four with no change for the group as a whole. Plasma osmotic pressure increased in seven of nine subjects, an average of 7 mosm/kg, a finding in keeping with the increase in plasma sodium.

Changes in plasma phosphate and protein are shown in Figure 4. Plasma phosphate fell in all seven subjects in whom the ion was measured; an average fall of 0.8 meq/liter occurred with a range from 0.25 to 1.8 meq/liter. Plasma protein remained unchanged in one subject and rose in all others, a finding reflecting the decrease in plasma and extracellular volume.

In Figure 5 the concentration of sweat Na and K are shown for the seven subjects in whom they were measured. Also shown in

Figure 5 is the estimated water losses, assuming, as is indicated by the data in Figure 2, that 93% of the weight loss was water, and the total loss of sodium and potassium estimated by multiplying the water loss by the concentration of sodium and potassium in sweat. While such a computation is subject to many errors, it does give a rough estimate of the magnitude of electrolyte and water depletion.

Figures 6 and 7 show the changes in blood glucose and serum lipids in four individuals subjected to vigorous exercise for 30 minutes. A progressive fall in glucose and rise in lipids occurred in all during exercise, while glucose rose and lipids fell during the recovery period.

Gastric physiologists have been aware for some time that water must be absorbed from the GI track as an isotonic solution and, for this reason, when water alone is ingested, a prolonged period of equilibration is necessary within the confines of the stomach and small bowel before transport occurs into the general circulation and volume replacement becomes available. During this time lag, the water remains in the stomach and small bowel and cramps occur when the water is sloshed around. Since individuals lose water in excess of salt when they perspire, and the body becomes concentrated in salt, it is desirable to replace the lost fluid via a solution which, contrary to present practice, provides more water than salt and at the same time is an isotonic solution which will be absorbed rapidly into the system.

In short, people have long been trying to find a solution to heat exhaustion, fatigue and dehydration. If water, which is hypotonic, is ingested, it remains in the stomach and small bowel until sufficient electrolytes are drawn from the system to make the solution isotonic. If one exercises during this time lag, cramps, nausea and vomiting are likely to ensue. If hypertonic liquids such as Coca-Cola (Registered Trade Mark) are ingested, the liquid is not absorbed until sufficient water is drawn from the system to render the solution isotonic. This, in effect, merely further dehydrates the system. If salt tablets are ingested, they merely aggravate the present condition of a high salt concentration. Therefore, none of the known methods commonly used provide a solution to the problem.

The present invention contemplates a composition of matter which, when made up to its proper dilution, provides an isotonic solution simulating the concentrations and compositions of body fluids lost in perspiration. The composition may be prepared in powder, liquid, concentrate or tablet form.

In one embodiment, the present invention provides a solution which can be ingested *ad lib*, that is, as much and as often as desired, and which is rapidly absorbed into the system and replaces fluid, salts and minerals lost during physical activity in the quality and quantity lost.

A solution in accordance with the present invention should contain the following:

from 16.5 to 26 meq. Sodium/liter (.3795 to .5980 gms/liter),

from 1.5 to 4.7 meq. Potassium/liter (.0587 to .1369 gms/liter),

from 11.9 to 19.9 meq. Chloride/liter (.4165 to .6965 gms/liter),

from 4.1 to 10.1 meq. Phosphate/liter (.1283 to .3161 gms/liter),

and from 30 to 60 gms/liter of glucose to maintain the isosmotic nature of the solution. In addition to the above, the solution may contain flavoring and sweetening agents. The sweetening agents which are preferred are the artificial sweetening agents such as, Sodium Saccharin, or combinations thereof. Natural sweetening agents such as Sucrose can be considered and used up to a level where they do not interfere or increase the isosmotic nature of the composition in relation to body fluids. If this isosmotic level is passed, then you are progressively decreasing the benefits derived from the use of such an isotonic solution.

Electrolyte solutions have been used in the past to treat acute dehydration. For example, " Extra Pharmacopoeia : Martindale " 25th Edition, published in 1967 by the Pharmaceutical Press, London, describes on page 506 several oral solutions of electrolytes and dextrose.

These solutions all differ from the solutions and compositions of the present invention, especially in that the former contain a much higher proportion of potassium than the latter. The reason for this is that the solutions described in the "Extra Pharmacopoeia" are intended for use in treating infants for electrolyte losses from the gastrointestinal tract, rather than for treating adult athletes for electrolyte losses through the sweat glands. Electrolyte losses from the gastrointestinal tract and through the sweat glands are not comparable. Moreover, infants undergo anabolic metabolism which requires large amounts of potassium, while athletes undergo catabolic metabolism which releases large amounts of potassium. Thus the solutions described in the " Extra Pharmacopoeia " are unsuitable for the treatment of acute dehydration in athletes, and if ingested in quantity would lead to a high percentage of potassium in the intercellular spaces, and this would in turn lead to poor muscle tone and possibly cardiac arrest.

EXAMPLE I

A typical composition to be made up to 1

litre of solution in accordance with the present invention is as follows:—

1.10 grams NaCl (18.80 meq. Na^+ and 14.8 meq. Cl^-)
.15 grams NaH_2PO_4 (1.08 meq. Na^+ and 3.07 meq. $PO_4^{\equiv}$)
.15 grams $NaHCO_3$ (1.78 meq. Na^+)
.10 grams KCL (1.34 meq. K^+ and 1.35 meq. Cl^-)
.15 grams KH_2PO_4 (1.10 meq. K^+ and 3.15 meq. $PO_4^{\equiv}$)
1.75 grams Citric acid
.25 grams Calcium cyclamate
40.00 grams Glucose
10.00 grams Sucrose
.40 grams Orange flavouring

The above composition made up to 1 litre of solution would have the following ionic concentrations:

21.66 meq. Na^+
2.44 meq. K^+
16.15 meq. Cl^-
6.22 meq. $PO_4^{\equiv}$

The above concentrations are well within the preferred ranges disclosed in this invention and they insure the isotonic nature of the product to be consumed during periods of physical exertion.

Example II

One typical formulation of the above solution was prepared by mixing the following materials:

85 gms	NaCl (14.54 meq Na^+ 14.73 meq Cl^-)
15 gms	NaH_2PO_4 (1.08 meq Na^+ 3.26 meq $PO_4^{\equiv}$)
15 gms	KH_2PO_4 (1.10 meq K^+, 3.34 meq $PO_4^{\equiv}$)
10 gms	KCl (1.34 meq K^+, 1.36 meq Cl^-)
15 gms	$NaHCO_3$ (1.78 meq Na^+)
125 gms	Citric Acid
50 gms	Calcium Cyclamate
5,000 gms	Glucose
240 ml	Lemon Extract
20 ml	Lime Extract

Sufficient water to dilute the solution to 100 liters.

In solution the above composition would have the following ionic concentrations:

17.40 meq. Na^+/liter
2.44 meq. K^+/liter
16.09 meq. Cl^-/liter
6.60 meq. $PO_4^{\equiv}$/liter

The citric acid, lemon extract and lime extract serve as flavoring agents and, naturally, may be replaced by any suitable flavoring agent. Since glucose, which serves to transport sodium across the gut is not especially sweet, it is necessary to add a sweetening agent such as the calcium cyclamate, although it is perfectly obvious that any number of sweetening agents could be employed. For instance, sucrose may be added in the ratio of 1 gm sucrose for 2 gms of glucose. Still further substitutions may be made such as replacing all of the KH_2PO_4 by KCl.

However, when the electrolytes are present within the range set forth hereinabove, and the solution ingested ad lib, the problems of heat exhaustion, fatigue and dehydration diminish if not totally disappear.

In arriving at formulations and compositions for the products of this invention, it should be understood that we are not bound by any one formulation. We may arrive at our ratios of Na^+, K^+, Cl^-, and $PO_4^{\equiv}$ concentrations by a variety of ways and in the use of numerous salts. The important factor must be the concentrations of these ions which in water or stomach fluid will give the proper balance, ratio, and concentration. For example, in place of the sodium orthophosphate and potassium orthophosphate, we may use trisodium phosphate and tripotassium phosphate. In place of sodium bicarbonate and citric acid, we may use sodium citrate. Such alterations and substitutions, so long as they maintain the concentrations of Na^+, K^+, Cl^- and $PO_4^{\equiv}$ ions within the tolerances we have disclosed, are permissible in our formulations. The ad lib ingested solution must conform and comply to the requirements of composition and concentrations we have disclosed in order effectively to replace the losses of these ions from the body fluids on physical exertion.

Example III

Another typical composition which complies with this invention is as follows:

.85 gms	NaCl (14.54 meq. Na^+, 14.73 meq. Cl^-)
.15 gms	Na3C6H507 (1.74 meq. Na^+)
.15 gms	NaH2PO4 $.H_2O$ (1.08 meq. Na^+, 3.26 meq. $PO_4^{\equiv}$)
.10 gms	KCl (1.34 meq. K^+, 1.36 meq. Cl^-)
.15 gms	KH_2PO_4 (1.10 meq. K^+, 3.34 meq. $PO_4^{\equiv}$)
.50 gms	Calcium Cyclamate, Sodium Saccharin blend
50.00 gms	Dextrose
1.25 gms	Lemon-Lime Extract

and sufficient water to make 1 liter of solution.

The above solution, although replacing the Sodium Carbonate and Citric Acid with Sodium Citrate, nevertheless gives a composition well within the ionic concentration ranges disclosed in this invention.

The above composition would yield:

17.37 meq. Na^+/liter
2.44 meq. K/liter
16.09 meq. Cl^-/liter
6.60 meq. $PO_4^{\equiv}$/liter

Variations in flavoring agents, sweeteners, etc., are a matter of choice. Since glucose, which serves to transport Sodium ions across the intestinal wall, is not especially sweet, it is necessary to add artificial sweeteners and flavoring agents to insure palatability of the electrolyte solution.

Example IV

Another typical composition illustrating the variation in formulation which is possible while complying with this invention is as follows:

1.00 gms	NaCl (17.10 meq. Na^+ and 17.33 meq. Cl^-)
.15 gms	$Na_3C_6H_5O_7$ (1.75 meq. Na^+)
.40 gms	K_2HPO_4 (4.6 meq. K^+ and 6.96 meq. $PO_4^{\equiv}$)
.40 gms	Calcium Cyclamate and Sodium Saccharin Blend
40.00 gms	Dextrose
.85 gms	Citrus Fruit Extract

and sufficient water to make up 1 liter of solution.

This simplified formulation still meets the ionic concentration preferred and maintains the osmolarity requirements necessary for rapid transport from the gut.

The above solution would have the following ion concentrations:

18.85 meq. Na^+/liter
4.6 meq. K^+/liter
17.33 meq. Cl^-/liter
6.96 meq. $PO_4^{\equiv}$/liter

The preparation of various forms of this composition in specific concentrations and ratios which may be diluted to the required concentration before ad lib ingestion is also within the scope of this invention. For example, the above formula composition may be prepared in tablet, powder, or concentrate form which, when diluted with the proper amount of water, will form the product of our invention ready to be ingested.

Example V

As a practical example of usefulness in such packaging variations, the formulation of Example IV, before water was added to make 1 liter of solution, was packaged in paper and foil laminates to form a packet, much like packets which are used for sauces, spices etc. The content of each packet was such that the user could dissolve this powder in water and make 1 liter of solution to obtain the ready-to-ingest fluid having the proper balance of concentrations and ratios of the electrolytes needed in our invention. It is a decided advantage for campers, hikers, and military men to have the powder form of this invention which can be reconstituted to the proper form before ingestion. In other circumstances, it may be more feasible to prepare a concentrate of the formulation which, when diluted with the proper amount of water, will again reconstitute the right product for ingestion.

Example VI

Another example of packaging the ingredients of this invention in dry form to be diluted with water before usage is as follows:

Anhydrous Dextrose	47.25 gms	89.25%
Citric Acid (USP)	2.25 gms	4.27%
Salt	0.80 gms	1.52%
Sodium Saccharin	0.425 gms	.81%
Gum Acaccia and Brominated Oil Blend	0.319 gms	.61%
Sodium Phosphate, Monobasic	0.142 gms	.27%
Potassium Phosphate, Monobasic	0.142 gms	.27%
Sodium Bicarbonate	0.142 gms	.27%
Potassium Chloride	0.095 gms	.18%
Flavoring	0.344 gms	.66%

Coloring may be added if desired

The above composition is the dry pack ingredients for 32 fluid ounces of this invention. Water added to make up 32 ounces of finished product would maintain the ionic concentrations in the preferred range disclosed.

The total weight of the dry ingredients above can be packaged in 1 packet to make up

32 ounces of finished product or they can be divided into 4 equal parts so that each part can be added to an 8 oz. glass with water and make 1 portion of drink for an individual.

EXAMPLE VII

A typical concentrate was prepared in the following manner:

The dry ingredients of Example II were measured into mixing vessel but instead of adding sufficient water to dilute the batch to 100 liters of solution, only 10 liters of solution were prepared. This concentrate now formed, is used by diluting 1 part of concentrate to 9 parts of water before using. The reconstituted solution becomes essentially that described in Example II.

The concentrate is a convenient form of this invention. It can be readily diluted and used whenever and wherever it is required merely by the addition of the proper ratio of water.

EXAMPLE VIII

The dry ingredients of Example VI were thoroughly mixed and ground to a uniform particle size. The blend was then fed into a conventional tableting machine.* The tablet size was so arranged to produce 32 tablets from the dry ingredients. The tablets were made of this size so that for each ounce of water one could use a tablet for preparing a solution of this invention.

Packets of 4 tablets were made to be used for a 4 ounce cup of water as a typical convenience usage of the product.

Other variations of the size of tablet and the number packed are, of course, obvious to those versed in the art. The packaging convenience or form is just an extension of this invention and not a limitation of the invention.

With these examples and disclosure, we have attempted to show the variations which are possible within the scope of our invention. Those versed in the art will recognize that the variations of formulation, form, or method of preparation do not exclude one from the invention which is predicated on the proper concentrations of the ions required for proper body fluid balance and the osmotic pressure required for easy and rapid transport of such electrolyte solution by the ingester's body.

When a solution in accord with the teachings of this invention is ingested ad lib, that is, as much as the individual or athlete desires when he desires, the incidence of heat cramps in athletes performing for long periods of time in an adverse environment was reduced to zero. For instance, during the two days prior to the institution of the use of this solution on the practice field, seventeen athletes were hospitalized with heat prostration. After the institution of its use, no player required hospitalization for this problem. The overall performance of individual players and the team as a whole demonstrated a significant improvement, particularly in the latter stages of varsity games where fatigue becomes a major factor.

While it is very difficult to define all the parameters of the term so vague as that of "fatigue", it is felt that shifts in body fluid spaces and body electrolytes represent a significant deviation from the optimal physiologic state and, therefore, are objective factors to which fatigue may be attributed. Prevention of these deviations should be beneficial if a practical method is devised to correct them. The present invention provides such a method.

EXAMPLE IX

As a further embodiment of this invention, the products formulated and given as examples in this application can be modified to give a carbonated beverage type of product. For example, the product of Example II can be modified by a higher percentage of acid addition to lower the pH of the solution to below 3.0. This solution can now be carbonated much like the processing of carbonated beverages until about 2.0 volumes of Carbon Dioxide is absorbed by. one volume of the solution. The resulting carbonated drink is bottled and used in the same manner as other carbonated beverages. The slight fizz associated with such beverages is a convenient way of making the product more palatable and pleasant to drink.

In order to further stress the importance of the present invention, the following two tests were run:

*A Stokes-Eureka Tableting Machine.

EXAMPLE X

Subject I was studied before and after strenuous exercise without and with having ingested the solution of the present invention during the exercise period.

	W/O Ingesting the Solution		Ingesting the Solution Ad Lib	
	Before Exercise	After Exercise	Before Exercise	After Exercise
Weight	99 Kg	96.5 Kg	99 Kg	99 Kg
Extracellular Volume	21 liters	19.6 liters	21 litres	21 liters
Plasma Volume	5.4 liters	4.7 liters	5.4 liters	5.4 liters
Serum Osmolarity	285 mOs/Kg	305 mOs/Kg	285 mOs/Kg	285 mOs/Kg
Sodium	141 meq/liters	147 meq/liters	141 meq/liters	141 meq/liters
Phosphate	4.9 mgm%	2.8 mgm%	4.9 mgm%	4.9 mgm%
Glucose (True-blood sugar)	78 mgm%	55 mgm%	78 mgm%	212 mgm%
Chloride	104 mgm%	116 mgm%	104 mgm%	102 mgm%

EXAMPLE XI

Subject II was studied before and after strenuous exercise without and with the method of the present invention.

	W/O Ingesting the Solution		Ingesting the Solution Ad Lib	
	Before Exercise	After Exercise	Before Exercise	After Exercise
Weight	104 Kg	100 Kg	104 Kg	104 Kg
Extracellular Volume	21.2 liters	18.4 liters	21.2 liters	21.2 liters
Plasma Volume	5.6 liters	4.6 liters	5.6 liters	5.6 liters
Serum Osmolarity	297 mOs/Kg	322 mOs/Kg	297 mOs/Kg	297 mOs/Kg
Sodium	146 meq/liters	154 meq/liters	146 meq/liters	139 meq/liters
Phosphate	5.5 mgm%	3.8 mgm%	5.5 mgm%	5.5 mgm%
Glucose (True-blood sugar)	80 mgm%	68 mgm%	80 mgm%	230 mgm%
Chloride	101 mgm%	114 mgm%	101 mgm%	100 mgm%

It can be seen from the above two examples that changes in weight, extracellular volume, plasma volume, serum osmolarity, sodium, phosphate and chloride are drastic during periods of vigorous exercise. However, when the method of the present invention is employed, no significant changes occur, the practical effect being that the usual heat exhaustion, fatigue and dehydration does not occur.

In conclusion, when people exercise and perspire, they lose fluids and electrolytes which must be replaced. The present invention provides a drink which replaces the lost substances in the quality and quantity they were lost. Therefore, the present invention provides a method whereby ingestion of an isotonic solution containing the substances which are lost during physical exercise and which is absorbed immediately has been provided.

WHAT WE CLAIM IS:—

1. A composition adapted to be mixed with water to form a beverage replacing fluid lost by an individual containing from 16.5 to 26 meq Na^+, from 1.5 to 4.7 meq K^+, from 11.9 to 19.9 meq Cl^-, from 4.1 to 10.1 meq $PO_4^{\equiv}$, and from 30 to 60 grams glucose for each liter of beverage.

2. A composition according to claim 1 adapted to be mixed with water to form a beverage containing 0.85 grams NaCl, 0.15 grams NaH_2PO_4, 0.15 grams KH_2PO_4, 0.10 grams KCl, 0.15 grams $NaHCO_3$, and 5.0 grams glucose, for each liter of beverage.

3. An aqueous beverage for replacing fluid lost by an individual during periods of vigorous physical activity in the quality and quantity lost, containing from 16.5 to 26 meq Na^+, from 1.5 to 4.7 meq K^+, from 11.9 to 19.9 meq Cl^-, from 4.1 to 10.1 meq $PO_4^{\equiv}$, and from 30 to 60 grams glucose in each liter.

4. A beverage solution according to claim 3 additionally containing up to 10 grams of sucrose per liter.

5. A powder concentrate composition adapted to be dissolved in water to form a solution containing from 16.5 to 26 meq $Na^+/1$, from 1.5 to 4.7 meq $K^+/1$, from 11.9 to 19.9 meq $Cl^-/1$, from 4.1 to 10.1 meq $PO_4^{\equiv}/1$ and from 30 to 60 grams of glucose/1.

6. A liquid concentrate adapted for dilution with water to form an isotonic solution containing from 16.5 to 26 meq $Na^+/1$ from 1.5 to 4.7 meq $K^+/1$, from 11.9 to 19.9 meq $Cl^-/1$, from 4.1 to 10.1 meq $PO_4^{\equiv}/1$ and from 30 to 60 grams of glucose/1.

7. A composition according to claim 1 wherein said solution contains absorbed carbon dioxide.

8. A composition according to claim 7 having a pH below 3.0.

9. A composition according to any of claims 1, 2, 5, 7 or 8 including at least one artificial sweetening agent.

10. A composition according to any of claims 1, 2, 5, 7, or 8 including at least one artificial flavouring agent.

11. A composition substantially as herein described with reference to the accompanying drawings.

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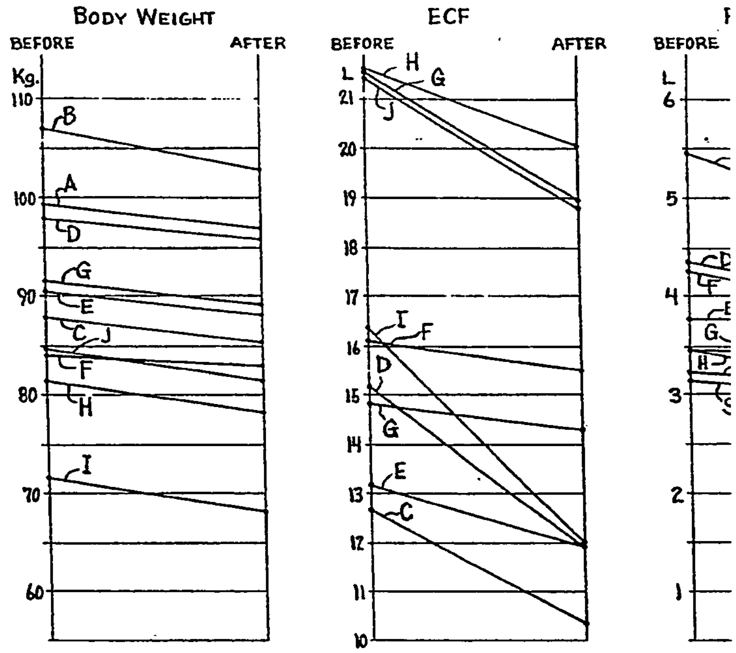

Fig. 1.

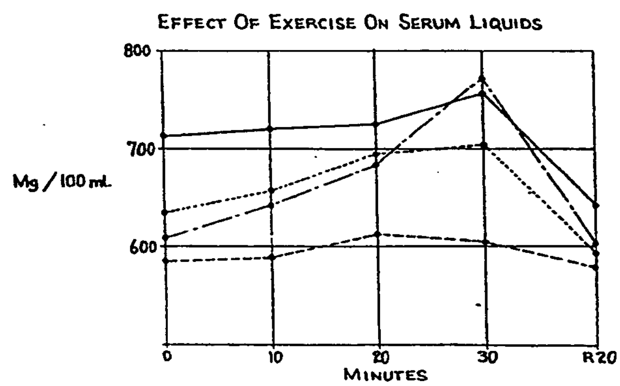

Fig. 7.

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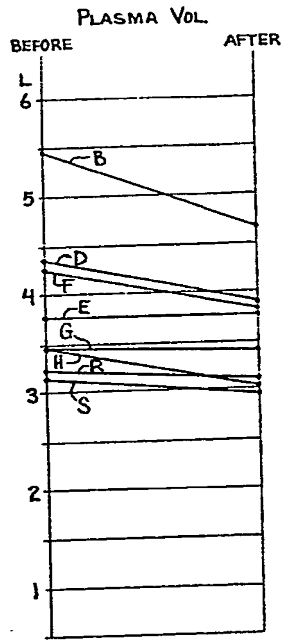


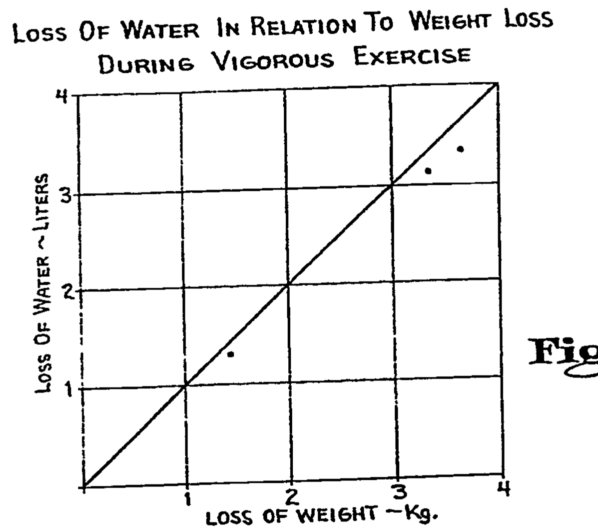


Fig. 2.

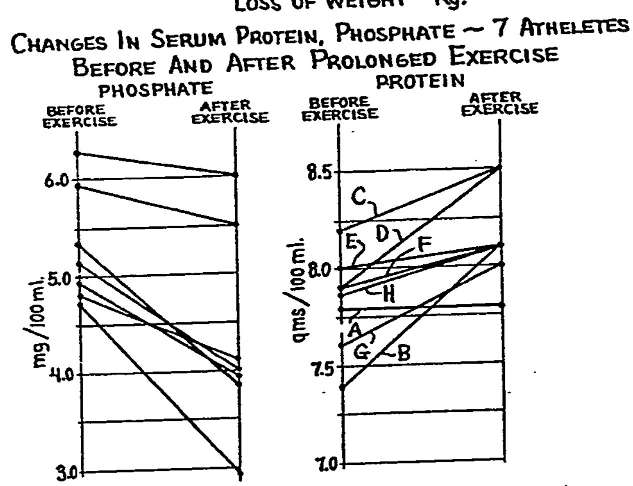
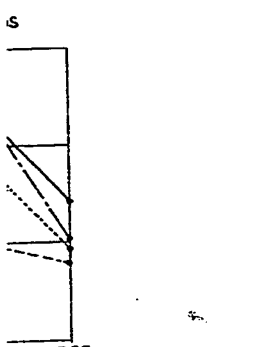


Fig. 4.



R20 = 20 min. Rest

1252781 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

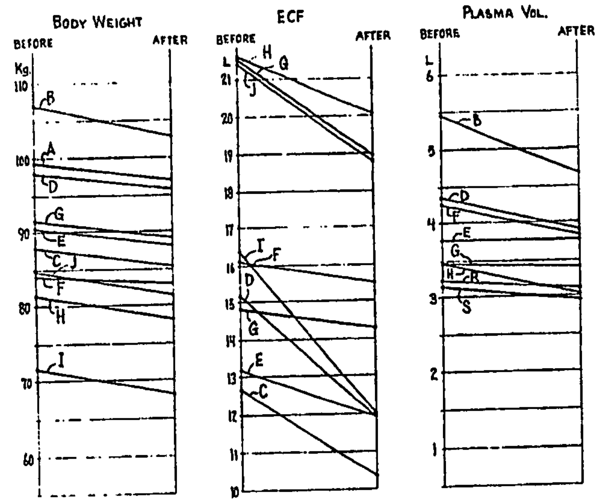


Fig. 1.

Loss Of Water In Relation To Weight Loss During Vigorous Exercise

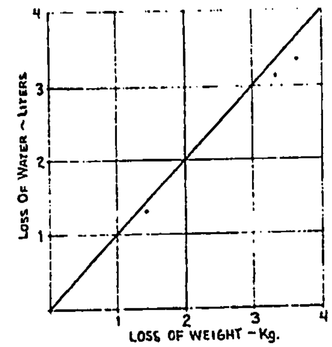


Fig. 2.

Changes In Serum Protein, Phosphate ~ 7 Atheletes Before And After Prolonged Exercise

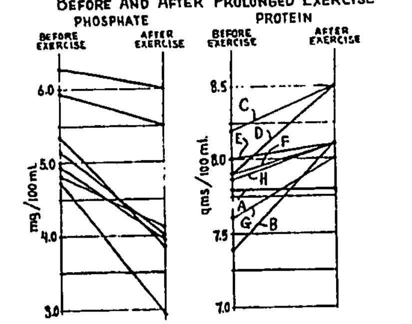


Fig. 4.

Effect Of Exercise On Serum Liquids

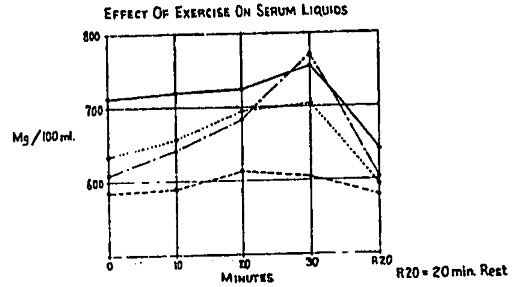


Fig. 7.

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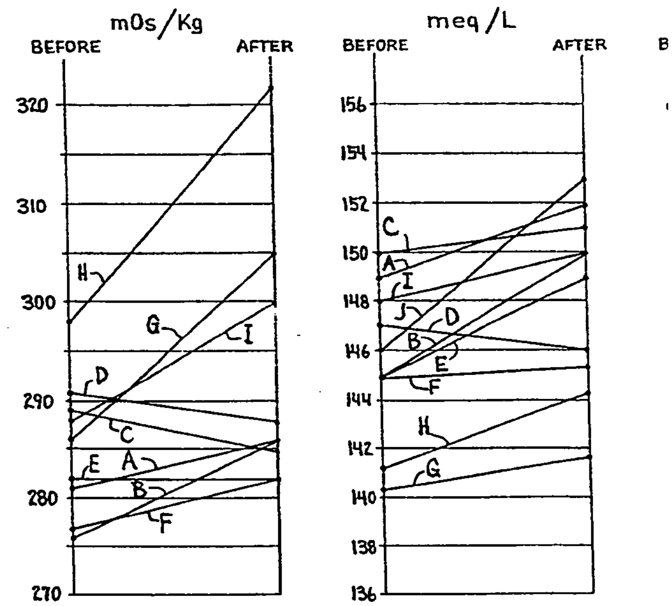

Fig. 3.

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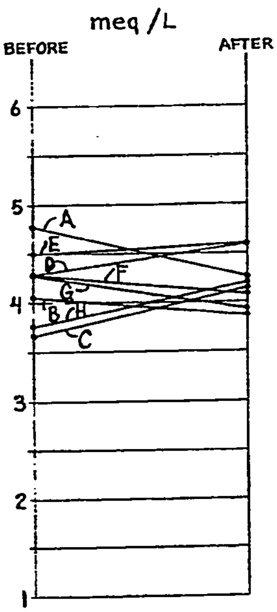

TB = TOTAL BODY

	H_2O LOSS LITERS	SWEAT Na^+	SWEAT K^+	Na^+ LOSS meq TB	K LOSS meq TB
A	2.1	41	24	86	50
B	3.3	114	41	375	136
C	2.0	—		—	—
D	2.8	87	61	243	171
E	1.9	—		—	—
F	1.3	—		—	—
G	2.1	63	49	132	103
H	2.9	65	65	188	188
I	3.06	79	15	241	46
J	2.70	64	10	173	27

Fig. 5.

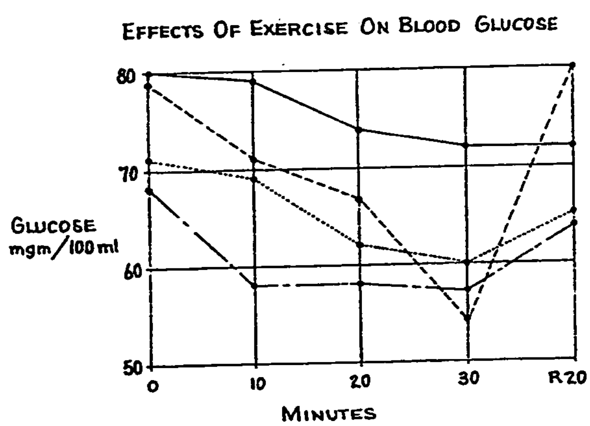

Fig. 6.

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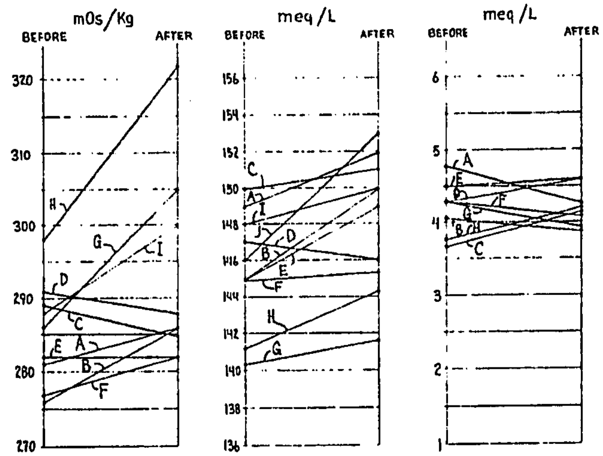

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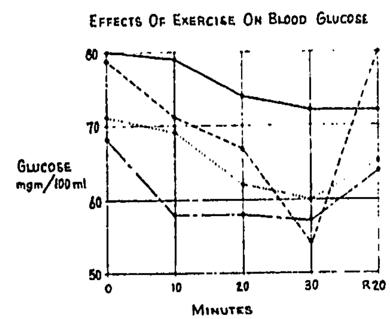

Fig. 6.